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Draft Memo

To:	Memo to File		
From:	David Clark, Michael Kasch	Project:	86197
CC:			
Date:	June 24, 2009, Rev. December 2, 2009	Job No:	

RE: Spokane River CE-QUAL-W2 Model Discharger Total Phosphorus Simulations with Variable Effluent Concentration

INTRODUCTION

Two scenarios were simulated using the CE-QUAL-W2 model of the Spokane River. The scenarios were set up to examine whether downstream dissolved oxygen concentrations would be different for constant versus variable total phosphorus discharges. The scenarios were: (1) a constant total phosphorus concentration from the dischargers; and (2) an equivalent annual loading but daily varying total phosphorus concentration from the dischargers.

MODEL

The Idaho and Washington CE-QUAL-W2 models of the Spokane River Version 3.6 were simulated using the w2_ivf.exe executable (6/4/2009 3:26pm) sent from Chris Berger, Portland State University. The results from the Idaho model were entered into the Washington model at Stateline to connect the two models.

SCENARIOS

Two simulations were run:

- Base model with discharger total phosphorus set to Flat 50 ug/l effluent total phosphorus
- Base model with discharger total phosphorus set with daily variable effluent phosphorus concentration based on a data set with a Coefficient of Variation of 1.2

The total phosphorus concentrations for seven dischargers were modified. The seven dischargers are:

- Coeur d’Alene WWTP
- Hayden
- Post Falls WWTP
- Liberty
- Kaiser
- Inland Empire Paper
- City of Spokane WWTP

Three model inputs were modified. The total phosphorus was partitioned between PO4 and BODP in the model input. Additionally, BOD was modified. For BOD, if the base model value was greater than 15 mg/L it was reduced to 15 mg/L and if it was less than 15 mg/L the base model value was used.

For the Flat 50 simulation the PO4 was set at 0.017 mg/L and the BODP at 0.033 mg/L (for a total TP of 0.05 mg/L) for all seven dischargers. The PO4 value was set based on a PO4/TP ratio of 34% based on the expected performance of future discharger treatment using the Coeur d’Alene low phosphorus pilot studies as a reference.

For the Coefficient of Variation simulation, the total phosphorus concentration was based on 2004 data from the Clean Water Services of Washington County, OR Durham Wastewater Treatment Plant. The Durham plant dataset is from May 10, 2004 through October 20, 2004 and covers the phosphorus control season for the Tualatin River. The total phosphorus mean of this dataset is approximately 0.1 mg/L. The values were reduced to achieve a mean of 0.05 mg/L for the Spokane River simulation. This string of data was appended multiple times to create one long chain of data to cover the Spokane River season. A random number generator was used to select starting points in the chain for each of the seven dischargers. This was done to both have 365 days of data for each discharger and to have each discharger with a unique variations in the dataset while all having the same mean of 0.05 mg/L and coefficient of variation of 1.2. The total phosphorus variation is shown in Figure 1. The total phosphorus concentration was than partitioned between PO4 and BODP using the PO4/TP ratio of 34% based on Coeur d'Alene low phosphorus pilot studies.

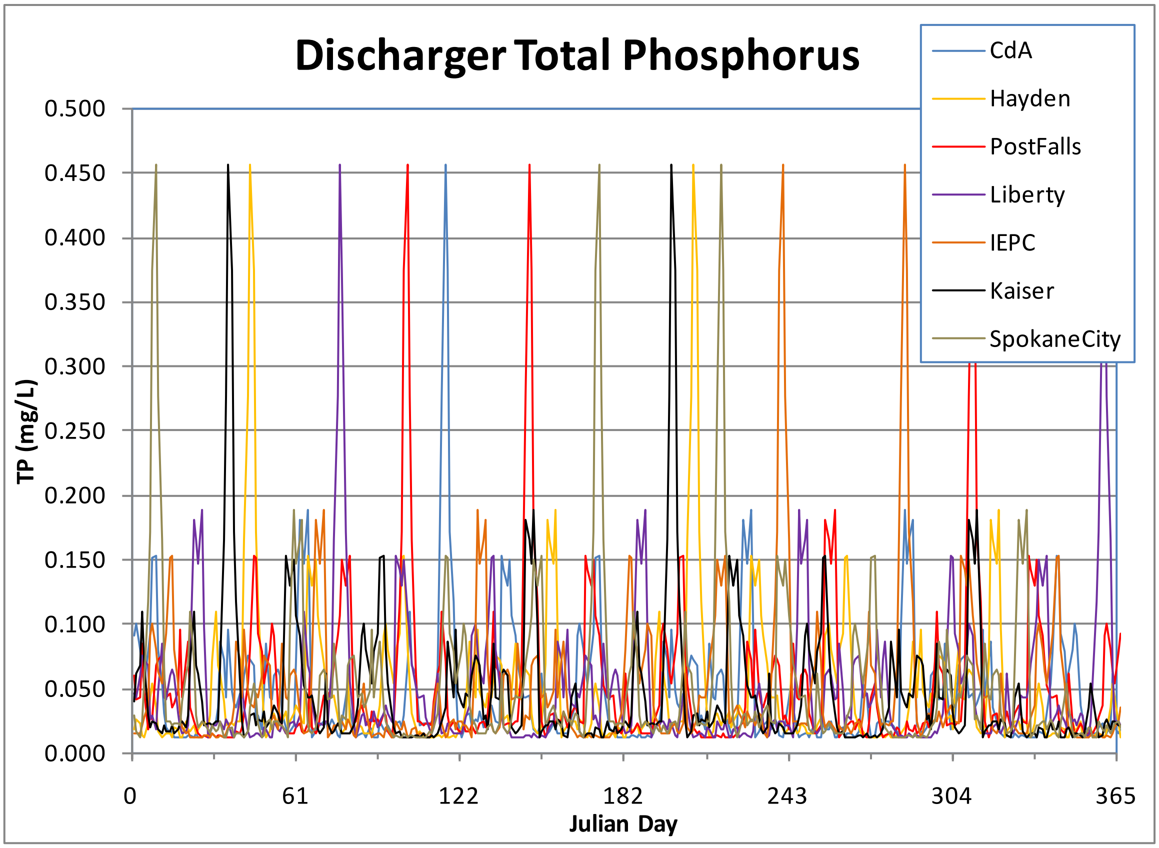

Figure 1. Variation in Total Phosphorus for each Discharger

RESULTS

The results were post-processed using the following steps. The dissolved oxygen was output at each segment of the reservoir, for all layers, every four hours. The dissolved oxygen in the top 8 meters was excluded. A volume-weighted average dissolved oxygen concentration was computed for each segment. The segments are 157 through 188, approximately the headwaters of Long Lake to Long Lake Dam. The minimum volume-weighted dissolved oxygen for each segment for each day was found. These daily minimums were then averaged over two week periods for each segment. The results are shown in Table 1. This presentation of the results is similar to those for the TMDL scenarios.

The delta between the two simulations shows a maximum depression in dissolved oxygen of 0.06 mg/L in any of the segments and an average increase of 0.01 mg/L. The maximum difference occurs near the headwaters but during a period of no spikes in the discharger total phosphorus concentrations. The results in the table are shown graphically in Figure 2.

The post-processing is by segment number and does not aggregate the dissolved oxygen into a single reservoir representative value. The segment results could be averaged; however, this would not include volume-weighting as the segments near the headwaters are smaller in volume than the segments mid-reservoir or near the dam.

CONCLUSIONS

Allowing for variation in the discharged total phosphorus, including maximum variations in concentrations above the in-stream target as high as 0.450 mg/l, results in similar dissolved oxygen conditions in the river and reservoir as predicted by the model. Variation in the effluent total phosphorus discharge is a more realistic representation of achievable advanced wastewater treatment for low effluent phosphorus. Including an allowable variation in the discharged total phosphorus is beneficial for practicable treatment facility operation while maintaining equivalent protection of river water quality. This sensitivity analysis demonstrates that it is unnecessary to limit maximum daily effluent phosphorus concentrations and that seasonal average limits at 50 ug/l provide equivalent water quality protection.

Table 1. Dissolved Oxygen Results for Long Lake, Flat 50 (50) v. Coefficient of Variation (CV) and the difference (Delta)

	50	CV	Delta	50	CV	Delta	50	CV	Delta	50	CV	Delta	50	CV	Delta	50	CV	Delta	50	CV	Delta	50	CV	Delta
Segment	June 1 -15			June 16 - 30			July 1- 15			July 16-31			August 1 - 15			August 16 - 31			Sept. 1 - 15			Sept. 16 - 30		
157	9.2	9.2	-0.01	9.2	9.2	0.03	9.0	9.0	-0.01	9.3	9.3	-0.02	9.3	9.5	0.16	9.5	9.5	-0.02	9.7	9.8	0.04	9.7	9.7	-0.04
158	9.4	9.4	-0.01	9.5	9.6	0.05	9.3	9.3	-0.01	9.5	9.5	-0.03	9.4	9.6	0.16	9.5	9.5	-0.03	9.8	9.8	0.04	9.7	9.7	-0.05
159	9.6	9.5	-0.01	9.6	9.6	0.04	9.3	9.3	-0.01	9.5	9.5	-0.03	9.4	9.6	0.15	9.5	9.4	-0.04	9.7	9.8	0.05	9.7	9.7	-0.05
160	9.7	9.7	-0.01	9.6	9.6	0.05	9.3	9.3	-0.01	9.5	9.4	-0.03	9.4	9.5	0.12	9.4	9.3	-0.05	9.6	9.7	0.06	9.7	9.6	-0.05
161	9.7	9.7	-0.01	9.6	9.7	0.05	9.3	9.3	-0.01	9.5	9.4	-0.03	9.4	9.5	0.14	9.4	9.3	-0.05	9.6	9.7	0.06	9.7	9.6	-0.05
162	9.7	9.7	-0.01	9.7	9.8	0.05	9.3	9.3	-0.01	9.4	9.4	-0.02	9.4	9.5	0.14	9.3	9.3	-0.05	9.5	9.6	0.06	9.6	9.6	-0.06
163	9.8	9.8	-0.01	9.8	9.8	0.06	9.3	9.3	-0.02	9.4	9.4	-0.02	9.3	9.4	0.14	9.2	9.2	-0.05	9.3	9.4	0.06	9.5	9.4	-0.05
164	9.8	9.8	-0.01	9.8	9.8	0.07	9.2	9.2	-0.02	9.3	9.3	-0.02	9.2	9.4	0.13	9.1	9.1	-0.05	9.2	9.2	0.05	9.3	9.2	-0.04
165	9.7	9.7	-0.01	9.7	9.8	0.08	9.1	9.1	-0.02	9.2	9.2	-0.02	9.1	9.2	0.14	8.9	8.8	-0.04	9.0	9.1	0.05	9.1	9.1	-0.04
166	9.7	9.7	-0.01	9.6	9.7	0.08	8.8	8.8	-0.02	9.0	9.0	-0.03	8.9	9.1	0.14	8.6	8.5	-0.04	8.9	9.0	0.05	9.0	9.0	-0.04
167	9.6	9.6	0.00	9.6	9.7	0.08	8.6	8.6	-0.02	8.8	8.7	-0.03	8.7	8.9	0.14	8.3	8.3	-0.03	8.8	8.8	0.05	8.9	8.9	-0.04
168	9.6	9.6	0.00	9.5	9.6	0.07	8.4	8.3	-0.02	8.3	8.3	-0.02	8.3	8.4	0.13	7.9	7.9	-0.03	8.7	8.7	0.05	8.8	8.8	-0.04
169	9.7	9.7	0.00	9.5	9.5	0.07	8.2	8.2	-0.02	8.0	8.0	-0.02	8.0	8.1	0.11	7.6	7.6	-0.01	8.5	8.6	0.04	8.7	8.7	-0.04
170	9.8	9.8	0.00	9.4	9.5	0.06	8.1	8.1	-0.01	7.8	7.8	-0.03	7.8	7.8	0.09	7.4	7.4	0.00	8.2	8.3	0.04	8.6	8.5	-0.04
171	9.8	9.8	0.00	9.3	9.4	0.06	8.1	8.1	-0.01	7.7	7.7	-0.03	7.6	7.7	0.09	7.2	7.2	0.01	8.0	8.0	0.04	8.4	8.4	-0.04
172	9.7	9.7	0.00	9.1	9.2	0.05	7.9	7.9	0.00	7.3	7.3	-0.03	7.1	7.2	0.07	6.6	6.7	0.02	7.6	7.6	0.03	8.3	8.2	-0.05
173	9.6	9.6	0.01	9.0	9.0	0.04	7.7	7.8	0.00	7.0	7.0	-0.03	6.8	6.9	0.05	6.3	6.3	0.03	7.2	7.3	0.03	8.1	8.0	-0.05
174	9.5	9.5	0.01	8.8	8.8	0.04	7.5	7.5	0.01	6.7	6.7	-0.03	6.5	6.5	0.03	5.9	5.9	0.04	6.8	6.8	0.03	7.7	7.7	-0.05
175	9.4	9.4	0.01	8.7	8.7	0.03	7.4	7.4	0.01	6.5	6.5	-0.03	6.2	6.2	0.01	5.6	5.7	0.04	6.4	6.4	0.02	7.4	7.4	-0.04
176	9.3	9.3	0.01	8.6	8.6	0.02	7.3	7.3	0.01	6.4	6.4	-0.03	6.1	6.1	0.00	5.5	5.6	0.04	6.3	6.3	0.02	7.3	7.2	-0.04
177	9.0	9.0	0.01	8.2	8.2	0.01	6.8	6.8	0.02	5.7	5.7	-0.02	5.4	5.4	0.00	4.7	4.8	0.03	5.4	5.4	0.00	6.5	6.5	-0.04
178	8.9	8.9	0.01	8.0	8.0	0.01	6.6	6.6	0.02	5.6	5.5	-0.02	5.2	5.2	-0.01	4.6	4.6	0.03	5.2	5.2	0.00	6.2	6.2	-0.03
179	8.8	8.8	0.01	8.0	8.0	0.00	6.5	6.6	0.02	5.5	5.4	-0.02	5.2	5.2	-0.01	4.5	4.5	0.04	5.0	5.0	-0.01	6.1	6.1	-0.03
180	8.7	8.7	0.01	7.9	7.9	0.00	6.4	6.5	0.02	5.4	5.3	-0.02	5.1	5.1	-0.01	4.4	4.5	0.05	4.8	4.8	-0.02	5.8	5.8	-0.02
181	8.6	8.6	0.01	7.8	7.8	-0.01	6.4	6.4	0.02	5.3	5.2	-0.02	4.9	4.9	-0.01	4.4	4.4	0.05	4.5	4.5	-0.01	5.5	5.5	-0.02
182	8.6	8.6	0.01	7.8	7.8	-0.01	6.4	6.4	0.03	5.3	5.3	-0.02	5.0	5.0	-0.01	4.4	4.5	0.05	4.5	4.5	-0.01	5.2	5.2	-0.01
183	8.4	8.4	0.01	7.5	7.5	-0.01	6.2	6.2	0.02	5.1	5.1	-0.02	4.7	4.7	-0.01	4.2	4.2	0.04	4.0	4.0	0.00	4.6	4.6	-0.01
184	8.3	8.3	0.01	7.4	7.4	-0.01	6.2	6.2	0.02	5.1	5.1	-0.02	4.7	4.7	-0.01	4.2	4.2	0.03	4.1	4.1	0.01	4.3	4.3	0.00
185	8.2	8.2	0.01	7.3	7.3	-0.01	6.1	6.1	0.03	5.0	5.0	-0.02	4.6	4.6	-0.01	4.1	4.1	0.02	4.0	4.0	0.01	4.0	4.0	0.00
186	8.0	8.0	0.01	7.2	7.1	-0.01	6.0	6.0	0.02	4.8	4.8	-0.01	4.3	4.3	-0.02	3.9	3.9	0.01	3.7	3.7	0.01	3.5	3.5	-0.01
187	8.0	8.0	0.01	7.2	7.2	-0.01	6.0	6.1	0.02	4.9	4.9	-0.01	4.3	4.3	-0.02	3.9	3.9	0.00	3.7	3.7	0.02	3.5	3.5	-0.01
188	7.8	7.8	0.01	7.0	7.0	-0.01	5.9	5.9	0.02	4.7	4.7	-0.01	4.0	4.0	-0.02	3.6	3.6	0.00	3.4	3.4	0.02	3.0	3.0	-0.01

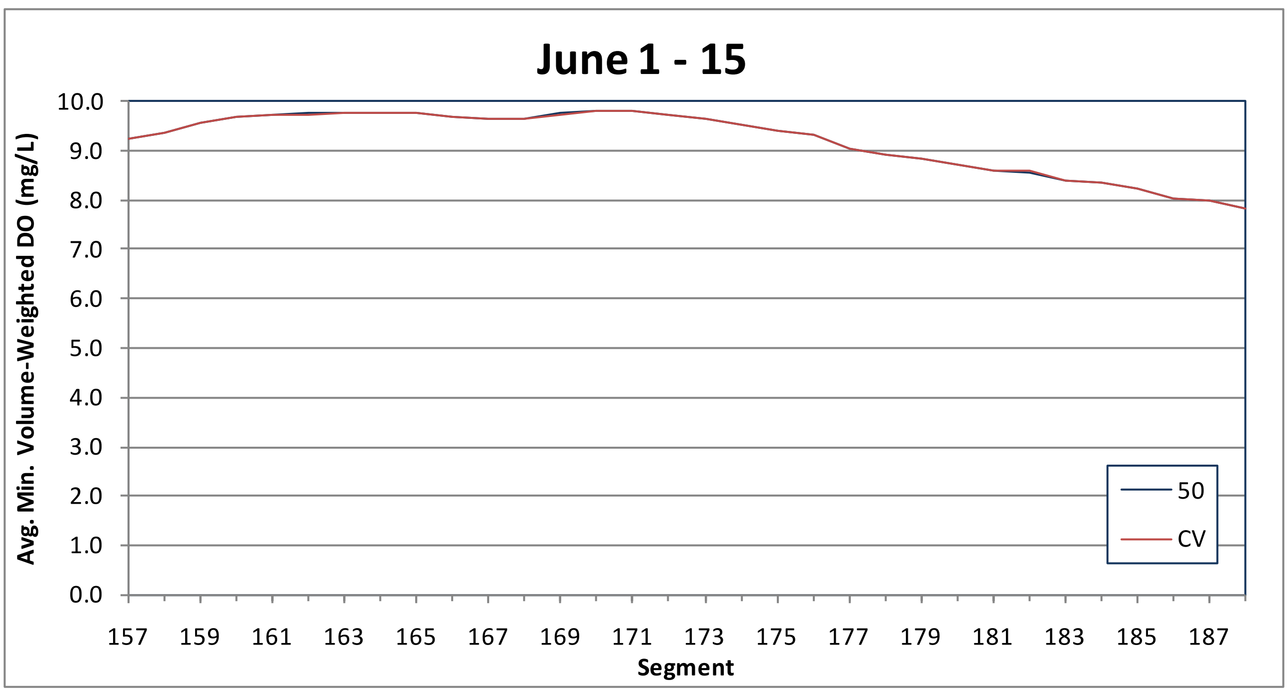

Figure 2a. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

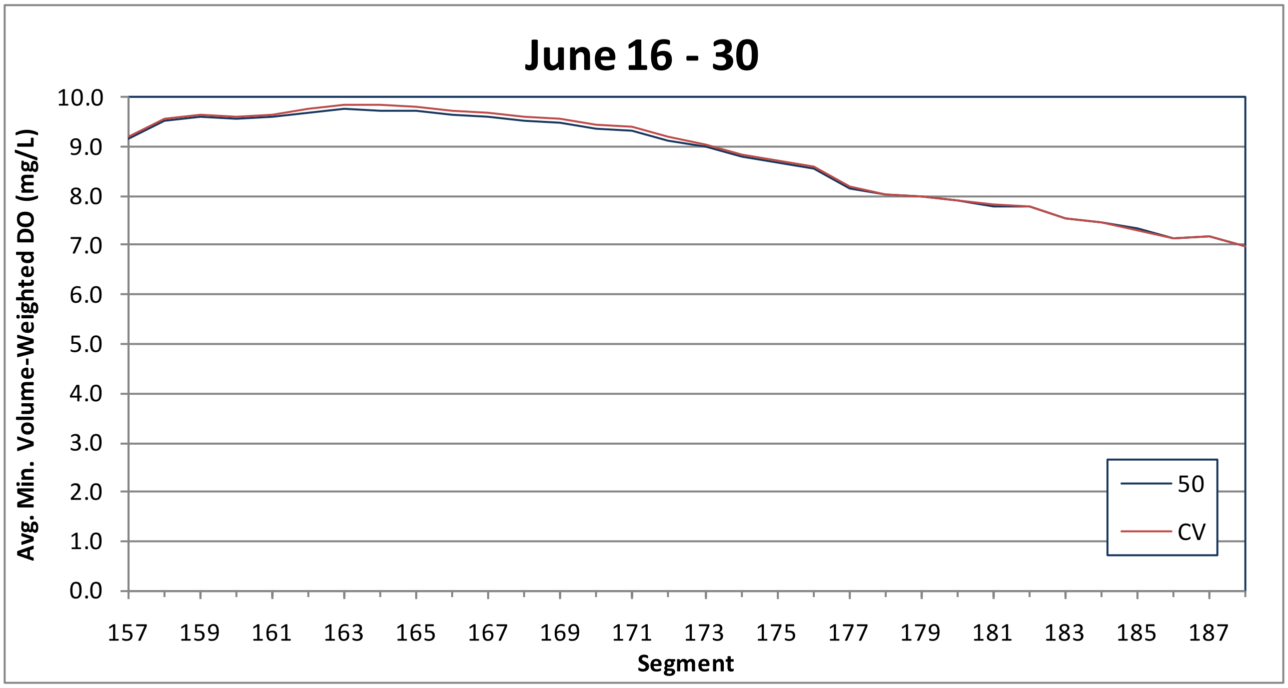

Figure 2b. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

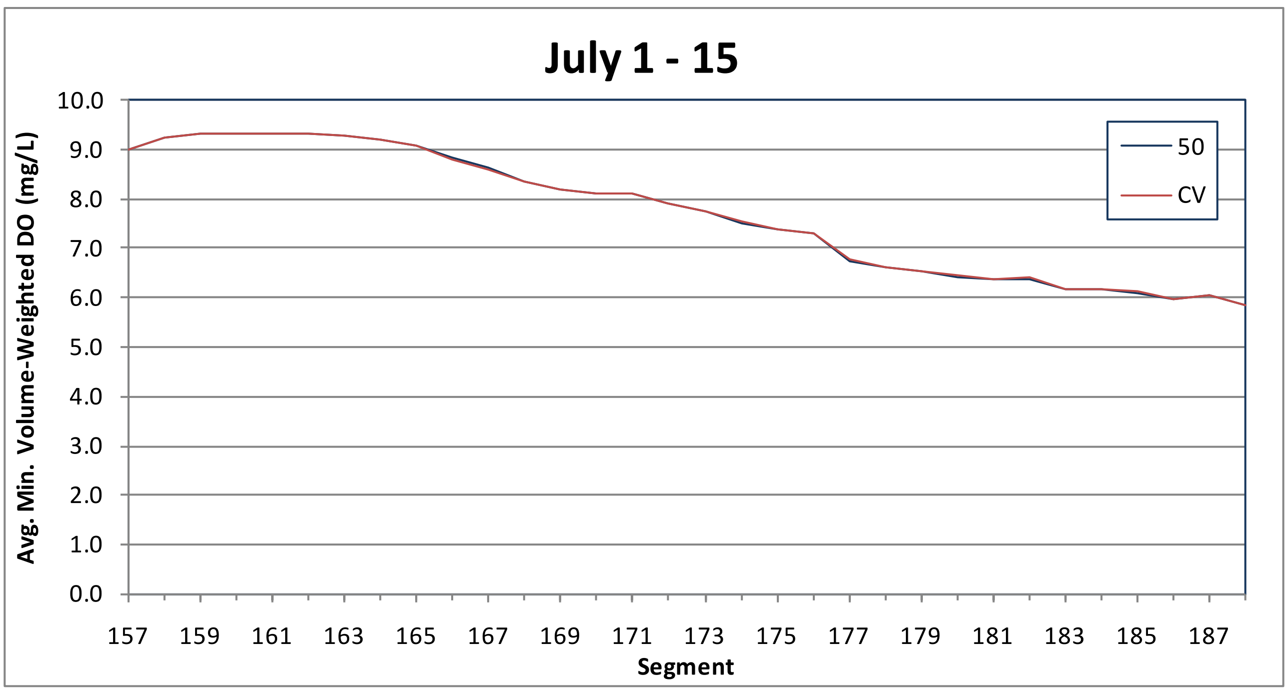

Figure 2c. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

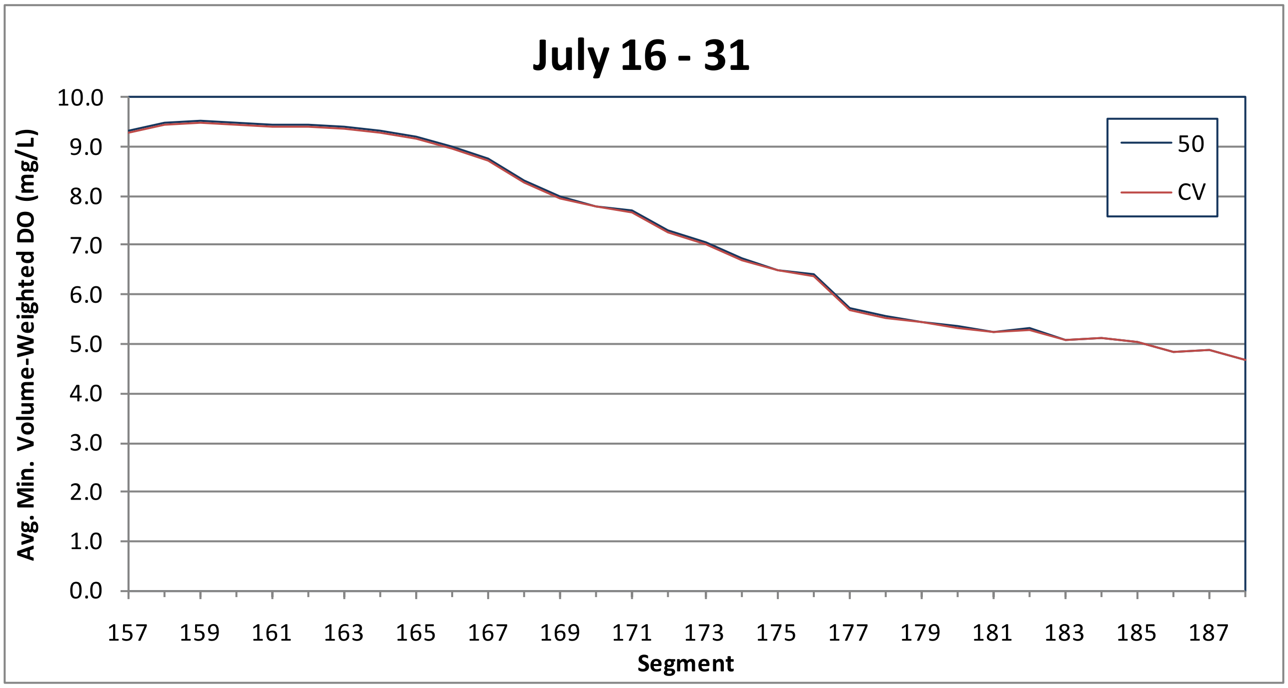

Figure 2d. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

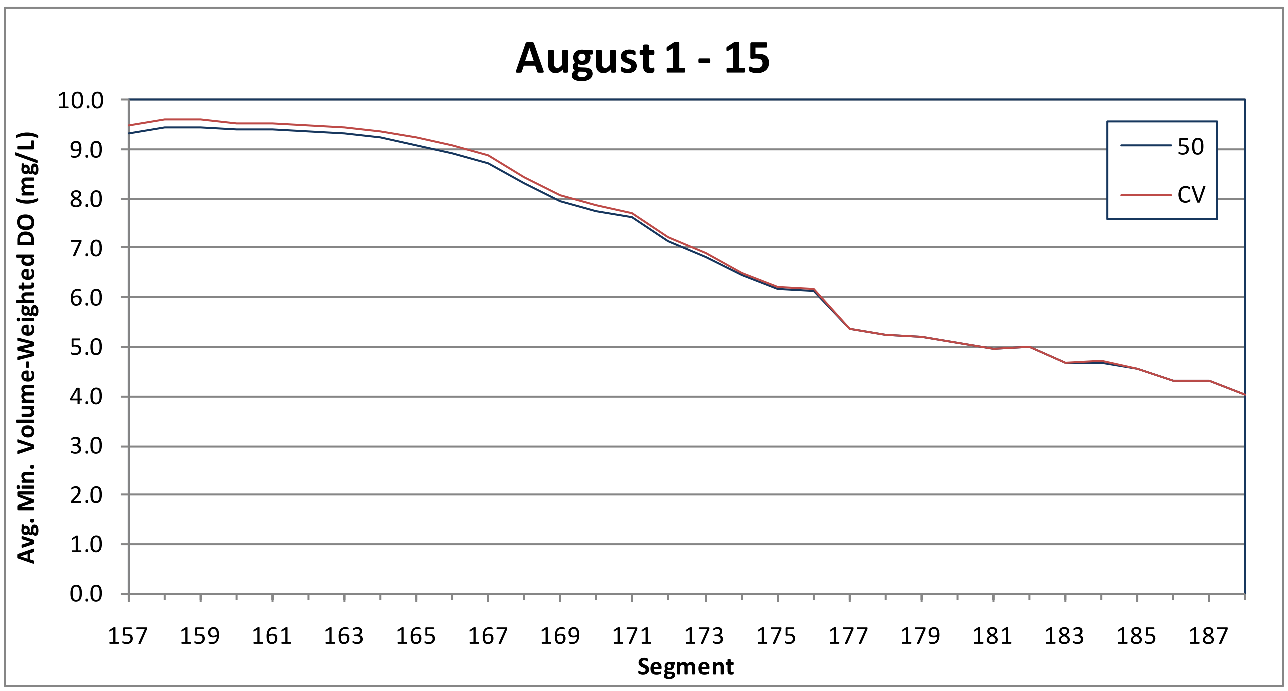

Figure 2e. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

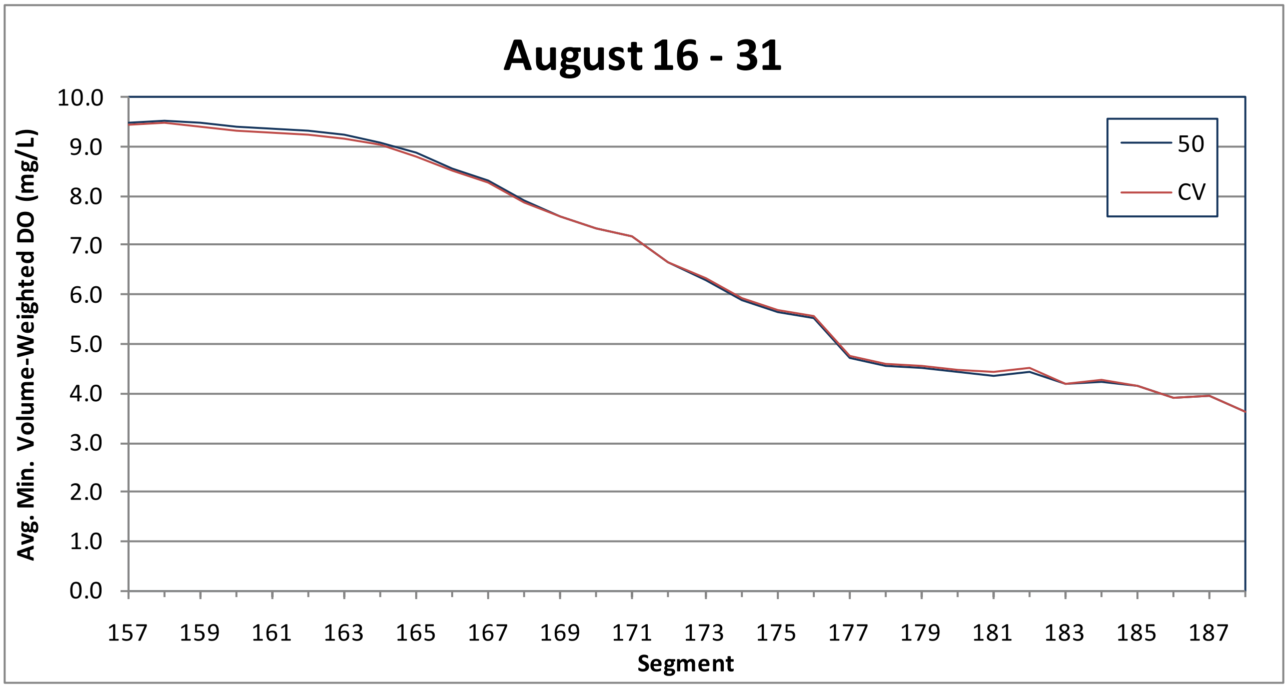

Figure 2f. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

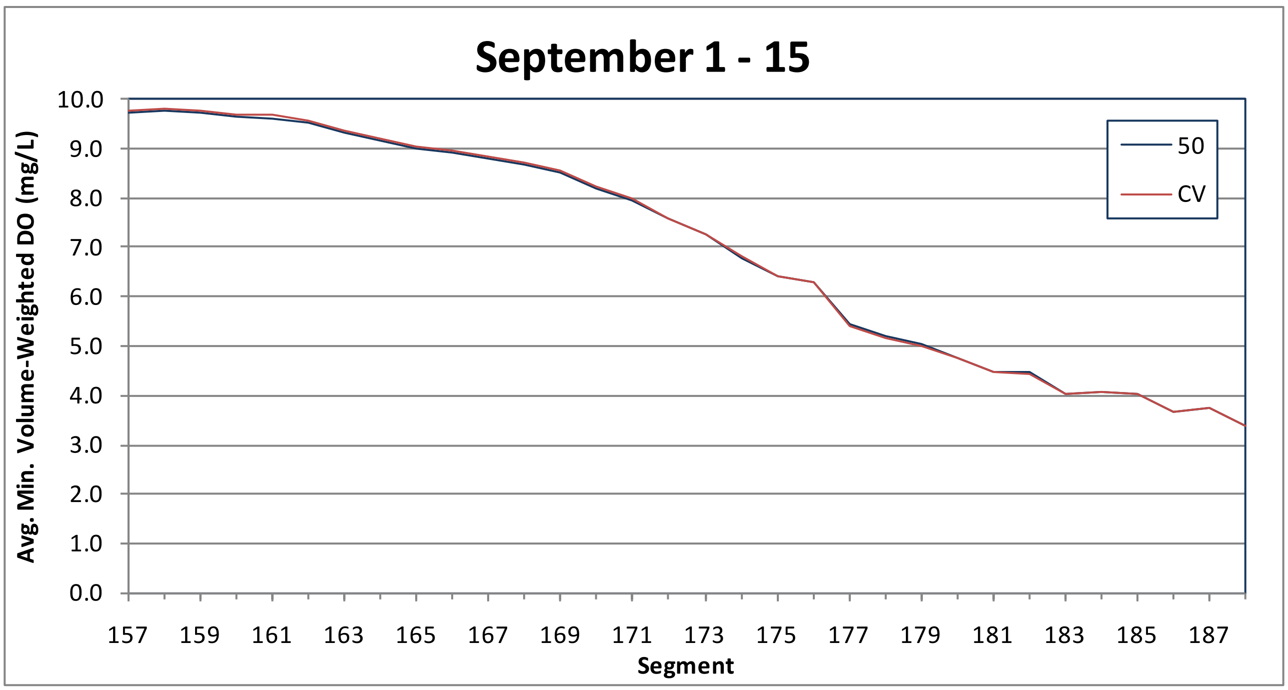

Figure 2g. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation

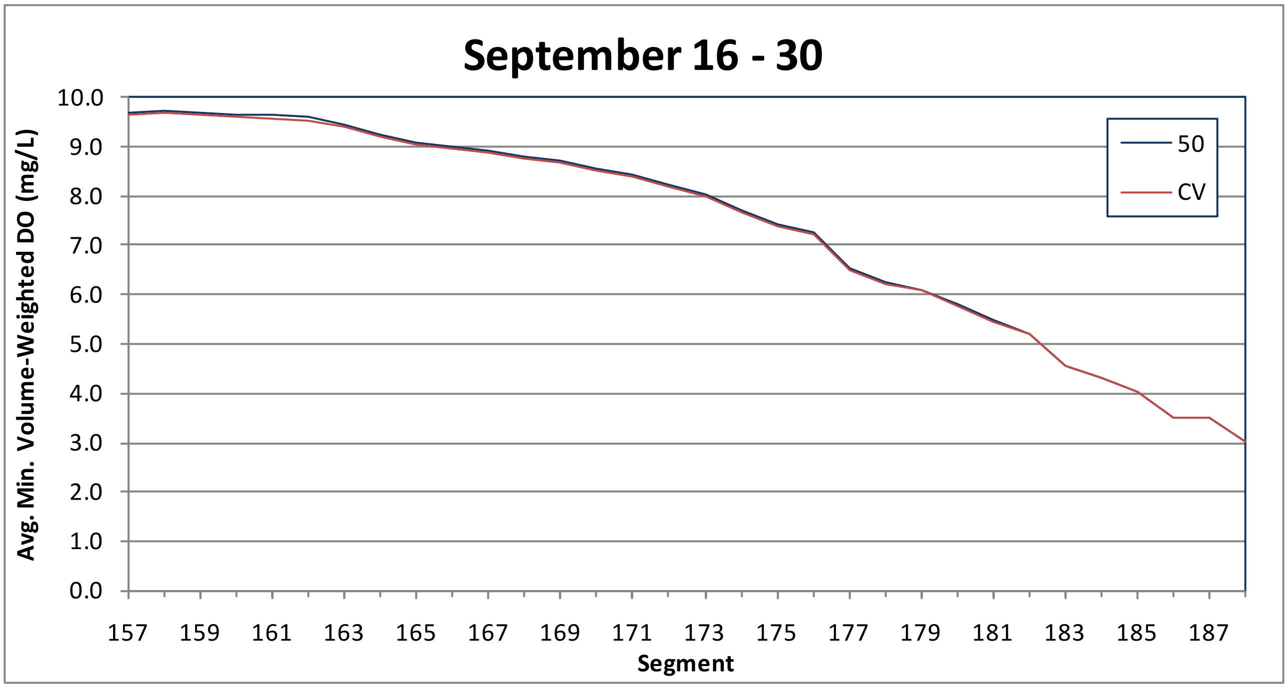

Figure 2h. Average Minimum Volume Weighted DO for Long Lake, Flat 50 v. Coefficient of Variation